SELENIUM CONTENTS IN TOBACCO AND MAINSTREAM CIGARETTE SMOKE

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SUMMARY

In the domain of essential trace elements the role of selenium is extremely important. As one of the volatile elements it can be partly absorbed through the pulmonary system during smoking and transported to different organs of the body. From this point of view a knowledge of its concentration levels in various sorts of tobacco and in the smoke of commercial cigarettes, as well as in the same type of cigarettes from plants treated with selenium is of interest for various research fields.

The purpose of this contribution is to present reliable quantitative data on contents in tobacco, soil and main stream cigarettes smoke, obtained by destructive neutron activation analysis.

INTRODUCTION

Microelements have vital roles in physiological processes in all living organisms. Among them in the last thirty years selenium is attracting more and more interest. As an essential element selenium induces a series of favourable effects, including functions such as direct influence on vitamin C synthesis, substitution for vitamin E, as well as antagonistic effects towards toxic heavy metals and an important role as constituent part of the enzyme glutathione peroxidase which catalyses the destruction of peroxides in organisms (1) For efficient functioning of selenium in living organisms, concentration levels of 0.04 - 0.1 ppm in the diet are necessary; on the other hand, with excess quantities of this element toxic effects can result (2). Accordingly, in many biomedical and environmental research areas the increasing awareness of the role of trace selenium in human and animal health has stimulated interest in investigation of its concentration

2023118366

levels in a wide spectrum of food articles, including tobacco, which holds an important position as an article of human consumption. Some research linked to tobacco studies show the physiological effects of selenium on man in areas with higher selenium content in tobacco (Mexico) than in areas of lower selenium content (USA) (3,4).

Hence in the present work some investigations on selenium in tobacco, including observation of the growth and development of tobacco plants (Burley: sort Čulinec and B 21) treated with selenium by soil amendment and foliar application were performed. Further, the determination of the concentration levels of selenium in treated tobacco and in different types of tobacco from various geographical areas was carried out, as well as the selenium content in main stream smoke of some commercial cigarettes or in the smoke of the same type of cigarettes with additional amounts of selenium.

EXPERIMENTAL

Selenium was analysed by destructive neutron activation analysis using radiochemical separations previously developed and checked in our laboratory (5-9).

Irradiation of homogenised (soil) or lyophilised (tobacco) samples and appropriate standards was performed in our TRIGA MARK II REACTOR for about 40 hours in the rotatory specimen rack at a neutron flux of 2×10^{12} $n.cm^{-2}.s^{-1}$.

Briefly, the radiochemical separation of selenium for soil samples is based on pyrolysis in a stream of air and oxygen, volatilization and trapping on soda lime (5). For tobacco the procedure is based on the destruction of the sample with a saturated solution of $Mg(NO_3)_2$, reduction of Se(VI) to Se(IV) with 6 M HCl, and extraction with CCl_4 of the chelate 5-nitro-2,1,3-benzo-selenadiazole resulting from the reaction between Se(IV) and 4-nitro-o-phenylene diamine (6,8,9).

Measurements of the gamma activity of the organic phase for ^{75}Se ($T_{1/2}$= 120 d; E_γ= 0.121; 0.136; 0.264; 0.400 MeV) in samples and standards were performed with a planar or "well type" HP Ge detector, connected to a multichannel analyser.
Chemical yields were shown by tracer experiments to be high (80 - 90 %).

RESULTS AND DISCUSSION

From the results of our investigations, presented in Tables 1 - 4, it is evident that:

1. The concentration levels of Se for common Burley, Prilep and Virginia tobaccos from different localities or geographical regions are rather similar. The small residual differences are probably due to differences in soil characteristics and genetic factors.
2. In cultivated Istrian Burley, treated with selenium via the soil or by foliar spray, the results show accelerated vegetation and growth, reflected in a lush green mass, in greater branching of roots, in a higher stalk and a larger number of leaves and their dimensions, in early blooming and a larger crop, etc. Further, differences in concentration levels of selenium between bottom, middle and upper leaves and their veins is also evident. In the case of higher concentration levels of added selenium from foliar application, no signs of phytotoxicity were observed.
3. The transfer of selenium from cigarettes prepared from Burley tobacco or from a standard tobacco mixture into main stream smoke and further into crude condensate depends on the design of cigarette, i.e. on the filtration capacity of the filter butts and on the porosity of the cigarette paper.

Concerning the clear phenomenon of the stimulative effects of selenium on tobacco growth, this element can be added by soil supplementation, especially in deficient areas, in the form of various fertilizers.

The accuracy of results obtained was checked by the analysis of different SRMs (Table 2) and good agreement was obtained. This proved the reliability of the radiochemical separation procedure for determination of Se in biological materials developed previously in our department. In the same way, analysis of shredded noncertified reference 2 RI Kentucky Tobacco was performed and the results obtained show a somewhat higher standard deviation, probably because of sample inhomogeneity.

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Table 1: Results for selenium ($\mu g/g$ dry weight) in soil and in untreated as well as SeO_2 treated Burley (sort Čulinec and B 21) tobacco, cultivated at Valtinjana and Sosiči

	Valtinjana 1, sort Čulinec				Sosiči, sort B 21	
	1984		1985		1988	
Soil: depth 20 cm	0.27		0.16		2.9	
depth 30 cm	1.10		0.84		3.2	
Position of tobacco leaves	control (untreated)	+ 5 mg Se/plant	control (untreated)	+ 5 mg Se/plant	control (untreated)	+ 20 mg Se/plant
sundy	0.230 ± 0.012	0.600 ± 0.020	0.233 ± 0.018	0.620 ± 0.024	0.554 ± 0.018	3.10 ± 0.17
cutters	0.124 ± 0.015	0.303 ± 0.020	0.170 ± 0.019	0.358 ± 0.025	0.440 ± 0.020	2.10 ± 0.19
leaf	0.074 ± 0.018	0.273 ± 0.015	0.075 ± 0.015	0.281 ± 0.096	0.245 ± 0.019	2.40 ± 0.15
tips	0.072 ± 0.011	0.163 ± 0.012	0.062 ± 0.011	0.179 ± 0.018	0.284 ± 0.022	1.90 ± 0.10
stem	0.035 ± 0.010	0.102 ± 0.011	0.046 ± 0.011	0.095 ± 0.015	0.090 ± 0.020	1.30 ± 0.12
$\bar{x}$ 1-5	0.106 ± 0.076	0.288 ± 0.192	0.117 ± 0.081	0.307 ± 0.202	0.360 ± 0.100	2.16 ± 0.66
Kv %	71.7	66.8	69.0	65.7	54.0	31.0

Table 2: Selenium content in Virginia, Burley and Oriental tobacco types from different geographical regions, in µg/g dry weight

Tobacco type	Geographical region	Se (µg/g)
VIRGINIA	Virovitica 1 BO	0.030
	Podravska Slatina 2 A	0.035
	Orašje 1 SL/ST	0.062
	Zimbabwe A 13	0.030
	Zimbabwe E 72	0.035
	Zimbabwe HN 34	0.046
	Zimbabwe A 22	0.052
	Zimbabwe A 12	0.073
	$\bar{x}$	0.045
	σ	0.016
	Kv %	35.0
BURLEY	Virovitica 3	0.079
	Zrenjanin 1	0.102
	Paraguai	0.053
	Orašje	0.055
	$\bar{x}$	0.072
	σ	0.023
	Kv %	32.0
ORIENTAL	Pirot - Prilep 1/4	0.079
	Bitola - Prilep 3	0.095
	Strumica - Jaka 3	0.093
	Radoviš - Jaka 1/4	0.072
	$\bar{x}$	0.085
	σ	0.011
	Kv %	13.0
NBS SRM 1572 Citrus Leaves	$R \pm \sigma$	0.027 ± 0.003
	n	4
	c.v.	(0.025)
NBS SRM 1577 A New Bovine Liver	$R \pm \sigma$	0.690 ± 0.020
	n	4
	c.v.	0.710 ± 0.070
NBS SRM 1568 Rice Flour	$R \pm \sigma$	0.340 ± 0.010
	n	6
	c.v.	0.400 ± 0.100
Kentucky Tobacco 2 RI	$R \pm \sigma$	0.083 ± 0.019
	n	6

n = number of determinations

c.v. = certified value

Table 3: Selenium content in Burley tobacco (sort B 21), treated with SeO_2 by foliar application, from locality of Sosiči, 1988 (µg/g dry weight)

Leaf position	+ 3 mg Se/plant	+ 9 mg Se/plant	+ 42 mg Se/plant	+ 116 mg Se/plant
cutters	7.1	17.5	106.0	443.2
leaf	9.2	30.9	169.3	411.8
tips	9.5	20.9	137.3	411.3
x 1-3	8.6 ± 1.3	23.1 ± 6.4	137.6 ± 31.7	422.1 ± 18.3
Kv %	15.2	30.2	23.0	4.3

Table 4: Selenium content in main stream smoke of cigarettes (Burley and standard mixture)

Cigarette B_0, R_{20}	Tobacco (µg/cig)	Crude condensate (µg/g)	Transfer %
$B_0F_{32}P_{25}$	0.079	0.0087	11.0
$R_{20}F_{24}P_{10}$	0.068	0.011	16.2
$R_{20}F_{32}P_{25}$	0.072	0.008	11.1
$R_{20}F_{44}P_{42}$	0.073	0.006	8.2
$R_{20}F_{44}P_{70}$	0.070	0.006	8.6
$R_{20}F_{44}P_{150}$	0.069	0.004	5.8
$R_{20}F_{44}P_{100}$ + 7 ug Se/cig	7.4	0.267	3.6

B_0 = Burley

R_{20} = Standard mixture

F = filtration (%)

P = porosity CU

2023118373